NASA SBIR/STTR Technologies

S4.04-9709 - Radiation-Hardening of Best-In-Class SiGe Mixed-Signal and RF Electronics for Ultra-Wide Temperature Range

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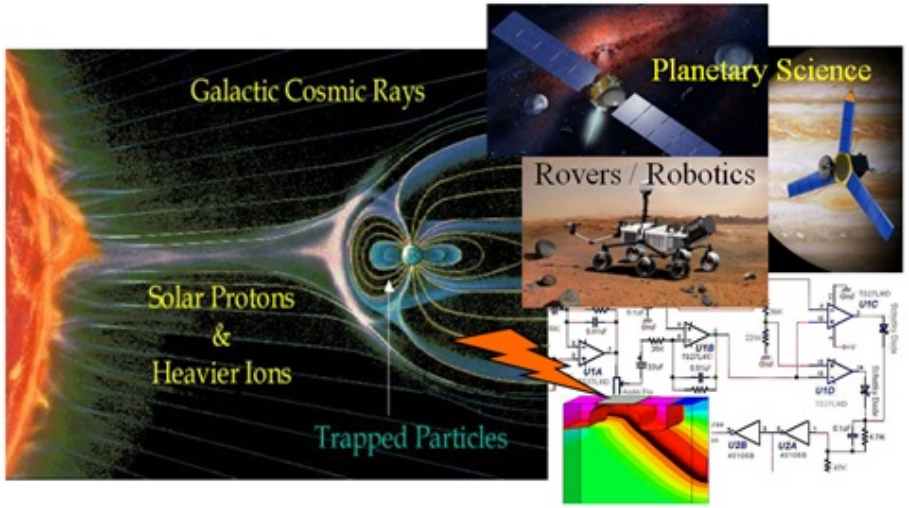
Identification and Significance of Innovation

NASA space missions need reliable, low-power, low-noise, RF electronics that can operate over a wide temperature range (wide-T, -230 to +130 deg C) and high radiation. Silicon-germanium (SiGe) - a robust IC technology with superior electronic properties, resilience to harsh environments, and moderate cost - can dramatically reduce mission size, weight, power and cost. The newest IBM 9HP SiGe platform enables highly integrated (sub) mm-wave applications not possible with earlier SiGe technologies. However, 9HP is yet to be tested in detail for wide-T and radiation effects and few data or simulation models exist.
Innovations: (1) Detailed characterization of best-in-class IBM 9HP SiGe RF electronics for extreme temperatures & transient radiation response. (2) Validated modeling tools for 9HP-based devices/circuits. (3) Novel Rad-Hard designs of mixed-signal/RF circuits, tested for extreme/low temperatures: will not require Warm Box and will decrease weight/cost of missions.



Estimated TRL at beginning and end of contract: (Begin: 3 End: 5)

Technical Objectives and Work Plan

OBJECTIVES: (i) Design, validate, and demonstrate innovative RHBD devices and mixed-signal/RF circuits in the best-in-class SiGe BiCMOS technology (IBM 9HP) and verified for environmental extremes; (ii) Develop reliable mixed-mode CAD tools and physics-based device models, enhanced and validated for the wide temperature range from -230 to +130 deg C, to support design and verification of rad-hard mixed-signal/RF circuits in the IBM 9HP SiGe platform.
WORK PLAN:
Phase I Results: 1) Investigated electrical performance of 9HP SiGe HBTs across an ultra-wide temperature range (-252 to +27 deg C); 2) Analyzed HBT-based circuit for single-event transient response via radiation testing and detailed mixed-mode simulations; 3) Identified RHBD techniques for further evaluation.
Phase II Tasks: 1) Select representative 9HP-based circuits from high-frequency and general purpose (analog/mixed-signal) applications, and perform electrical and radiation response characterization (DC and RF) across a wide temperature range, via testing and mixed-mode modeling; 2) Implement and verify RHBD techniques via detailed mixed-mode modeling; 3) Fabricate promising RHBD designs, perform radiation/temperature testing, and deliver prototypes to NASA; 4) Assess technology scaling effects on extreme environment performance of SiGe HBTs/circuits across different generations to support design/trade-off analyses.

NASA Applications

Per OCT TA08, radiation-hardened and wide-temperature mixed-signal/RF circuit technology development is aligned with the major flight programs within the Planetary Science Division: Discovery, New Frontiers, Lunar Quest, Mars Exploration, and Outer Planets Programs, including EJSM. Electronics operating in extreme environments without bulky and power inefficient protective shielding and heating/cooling infrastructure will make possible new investigations of the Solar System.

Non-NASA Applications

Various critical analog, mixed-signal, RF, and digital circuits used in all space-based platforms, including DoD space systems (communication, surveillance, ballistic missiles, missile defense), and commercial satellites. Also, cryogenic electronics for high-sensitivity, low-noise analog and mixed-signal applications, such as metrology, infrared (IR) imagers, and sensors.

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NON-PROPRIETARY DATA